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A Review on Methods Involved In the Preparation, Characterization and Applications of Solid Dispersions.

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ABSTRACT
Solid dispersion was introduced in the early 1970s, refers to a group of solid products consisting of at least two different components, generally a hydrophilic matrix and a hydrophobic drug. The term solid dispersion refers to a group of solid products containing at least two different components, generally a hydrophilic matrix and a hydrophobic drug. The matrix can be either crystalline or amorphous. The selections of carrier have a profound effect on dissolution characteristics of a drug. So, a water soluble carrier leads to faster release of drug from the matrix and a water insoluble carrier leads to slower release of drug from the matrix .The drug can be dispersed molecularly, in amorphous particles or in crystalline particles by melting or solvent method. In this review it has been clearly demonstrated about the preparative methods, merits, demerits and characterization of solid dispersions.

Keywords: Solid dispersions, Polymeric carriers, Applications, Characterization.

INTRODUCTION

Solid dispersion technology is the science of dispersing one or more active ingredients in aninert matrix in the solid stage in order to achieve increased dissolution rate.[1]

CLASSIFICATION OF SOLID DISPERSION

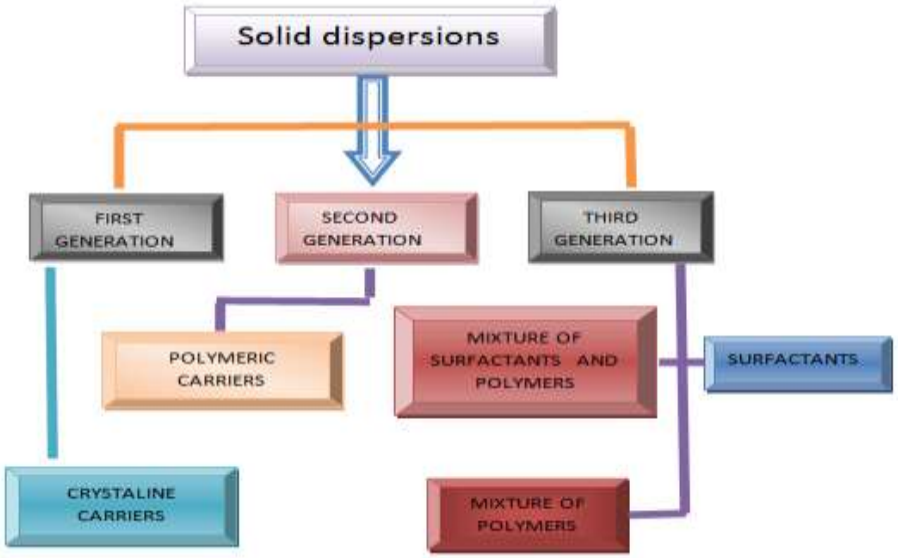

FIGURE.NO:.1 CLASSIFICATION OF SOLID DISPERSION

Solid dispersion is classified under 3 catagories
1.First generation solid dispersion
2.Second generation solid dispersion
3.Third generation solid dispersion

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a) First generation solid dispersions

The first description of solid dispersions was fromSekiguchi and Obi in 1961. Eutectic mixtures improves the rate ofdrug release and the bioavailability ofpoorly water soluble drugs. In the same decade, severalsolid dispersions were described using poorly watersoluble drugs, such as sulfathiazole andchloramphenicol using urea as high water solublecarrier. These solid dispersions produced faster releaseand higher bioavailability than conventionalformulations of the same drugs. The small particle sizeand the better wettability of the drug were the mainreasons for the observed improvements inbioavailability.Later, Levy and Kaning developed soliddispersion systems, containing mannitol as carrier, bypreparing solid solutions through molecular dispersionsinstead of using eutectic mixtures. The observedimprovements were attributed to a faster carrierdissolution, releasing microcrystals or particles of drug .These solid dispersions, which could be designedas first generation solid dispersions, were preparedusing crystalline carriers. Crystalline carriers includeurea and sugars, which were the first carriersto be employed in solid dispersions. They have thedisadvantage of forming crystalline solid dispersions,which were more thermodynamically stable and did notrelease the drug as quickly as amorphous ones.

b) Second generation solid dispersions

The drug was maintained in the crystalline state,might not be as effective as the amorphous, because theformer were more thermodynamically stable. Therefore, a second generation of solid dispersionsappeared, containing amorphous carriers instead ofcrystalline. Indeed, the most common solid dispersionsdo not use crystalline carriers but amorphous. In thelatter, the drugs are molecularly dispersed in anirregular form within an amorphous carrier, which are usually polymers. Polymeric carriers have been themost successful for solid dispersions, because they areable to originate amorphous solid dispersions. They aredivided into fully synthetic polymers and naturalproduct-based polymers. Fully syntheticpolymersincludepovidone (PVP),polyethyleneglycols (PEG) and polymethacrylates. Naturalproduct based polymers are mainly composed bycellulose derivatives, such ashydroxypropylmethylcellulose (HPMC), ethyl celluloseorhydroxypropylcelluloseor starch derivates, likecyclodextrins. In second generation soliddispersions, the drug is in its supersaturated statebecause of forced solubilization in the carrier.These systems are able to reduce the drug particle sizeto nearly a molecular level, to solubilize or co-dissolvethe drug by the water soluble carrier, to provide betterwettability and dispersibility of the drug by the carriermaterial, and to produce amorphous forms of the drugand carriers.

c) Third generation solid dispersions

These contain a surfactantcarrier, or a mixture of amorphous polymers andsurfactants as carriers. These third generation soliddispersions are intended to achieve the highest degreeof bioavailability for poorly soluble drugs and tostabilize the solid dispersion, avoiding drugrecrystallization. The use of surfactants such as inulin[2], inutec SP1 [42], compritol 888 ATO [46], gelucire44/14 [48] and poloxamer-407[47] as carriers was shownto be effective in originating high polymorphic purityand enhanced in vivo bioavailability. [2]

Advantages of Solid Dispersions:

Solid dispersions of a drug in solid state are helpful in stabilizing unstable of drug.

- Many advantages of solid dispersions are derived from their rapid dissolution rate.
- Solid dispersions are thermodynamically more active form of a drug and directly influences diffusion and release rate.
- The dose of drug that is given in solid dispersion form could be decreased; for example, the dose of reserpine spironolactone can be reduced to half by incorporating the drug in a solid dispersion form.
- Solid dispersion of drug in carriers of low solubility offers the potential for sustained release of drug.
- Cell toxicity of Acyclovir can be decreased by solid dispersion method.
- The ulcerogenic activity of NSAIDS can be decreased by solid dispersion method.
- An increased diffusion of steroid from the ointment was obtained, example Prednisolone urea ointment base.

Disadvantages of Solid Dispersions:

The limitations of this technology have been a drawback for the commercialization of solid dispersions, the limitations include

- Understanding the physics of amorphous materials
- Understanding the physical structure of solid dispersions

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- Prediction of shelf of amorphous materials is unknown.[3]

MECHANISM OF SOLID DISPERSION:

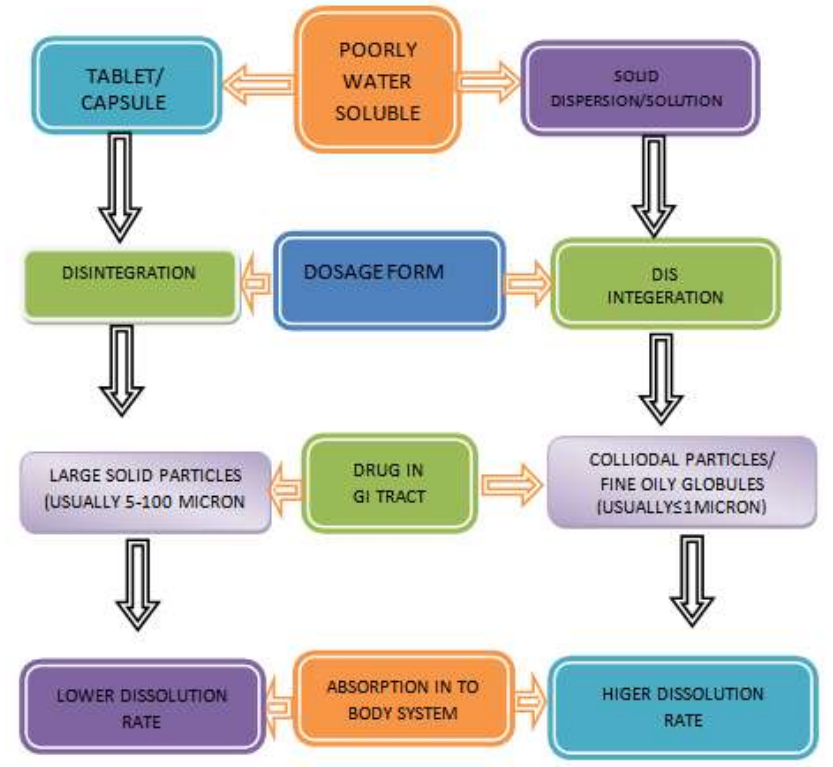

FIGURE.NO:2 MECHANISM OF SOILD DISPERSION

TYPES OF SOLID DISPERSION

SOLID DISPERSION TYPE	**MATRIX ***	**DRUG ****	**REMARKS**
1.Eutectics	C	C	The first type of solid dispersion prepared
2.Amorphous precipitations in crystalline matrix	C	A	Rarely encountered
3.Solid solutions			
➢ Continous solid solution	C	M	Miscible at all composition, never prepared.
➢ Discontinous solid solutions	C	M	Partially miscible, 2 phases even though drug is molecularly dispersed
➢ Substitutional solid solution	C	M	Molecular diameter of drug (solute) differs less than 15% from the matrix (solvent) diameter. In that case the drug and matrix are substitutionalcan be continous or discontinuous.

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			When discontinuous 2 phases even though drug is molecularly dispersed.
➢ Interstitial solid solutions	C	M	Drug (solute) molecular diameter less than 59% of matrix (solvent) diameter. Usually limited miscibility, discontinuous. Ex drug in helical interstitial spaces of PEG
4.Glass suspension	A	C	Particle size of the dispersed phase dependent on cooling/evaporation rate. Obtained after crystallization of drug in amorphous matrix.
5.Glass suspension	A	A	Particle size of dispersed phase dependent on cooling/evaporation rate. Obtained after crystallization of this type.
6.Glass solution	A	M	Requires miscibility or solid solubility, complex formation or upon fast cooling or evaporation during preparation. Many (recent) ex especially with PVP

*A: matrix in the amorphous state

*C:matrix in the crystalline state
**A:drug dispersed as amorphous clusters in the matrix
**C:drug dispersed ascrystalline particles in the matrix,
M: drug molecularly dispersed throughout the matrix.[2],[4]

SELECTION OF A CARRIER

A carrier should meet the following criteria to besuitable for increasing the dissolution rate of adrug.
1. Freely water-soluble with intrinsic rapid dissolution properties.
2. Non-toxic and pharmacologically inert.
3. Heat stable with a low melting point for the meltmethod.
4. Soluble in a variety of solvents and pass througha vitreous state upon solvent evaporation for thesolvent method.
5. Able to preferably increase the aqueoussolubility of the drug.
6. Chemically compatible with the drug and notform a strongly bonded complex with the drug.[5]

A) **First generation carriers**

These include - Sugars, organic acid, and urea .

B) **Second generation carriers**

These includes – Starch derivatives like cyclodextrins, Cellulose derivatives like ethylcellulose, hydroxypropylcellulose, hydroxypropylmethylcellulose and fully synthetic polymers like polyethylene glycols, povidone and polymethacrylates.

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C) **Third generation carriers**
These includes-Tween 80, poloxamer 408 andGelucire 44/127.[6],[7]

SOLVENTS:
Solvents to be included for the formulation of solid dispersion should have the following criteria:
1. Both drug and carrier must be dissolved.
2. Toxic solvents to be avoided due to the risk of residual levels after preparation e.g chloroformand dichloromethane.
3. Ethanol can be used as alternative as it is less toxic.
4. Water based systems are preferred.
5. Surfactants are used to create carrier drug solutions but as they can reduce glass transition temperature, so care must be taken into consideration.[8]

A) Class 1 Solvents (solvents to be avoided)
Solvents included in this class are not to be taken into use because of their deleterious environmental effects.

LIST OF SOME CLASS 1 SOLVENTS:

SOLVENT	CONCENTRATION LIMIT (PPM)	EFFECT
Benzene	2	
Carbon tetrachloride	4	Carcinogen toxic and environmental hazards toxic
1.2-dichloroethane	5	Toxic
1,1-dichloroethane	8	Toxic
1,1,1-trichloroethane	1500	Environmental hazards

B) Class 2 Solvents (Solvents to Be Limited)
These solvent should be limited used in pharmaceutical products because of their inherent toxicity.

CLASS 2 SOLVENTS IN PHARMACEUTICAL PRODUCTS

SOLVENT	PDE(mg/day)	CONCENTRATION LIMIT(PPM)
Chlorobenzene	3.6	360
Chloroform	0.6	60
Cyclohexane	38.8	3880
1,2-dichloroethane	18.7	1870
Ethylene glycol	6.2	620
Methanol	30	3000
Pyridine	2.0	200
Toluene	8.9	890

PDE = Permitted daily exposure

C) Class 3 solvents (solvents with low toxic potential)
Solvents included in this class may be regarded as less toxic and have the low risk to human health.

CLASS 3 SOLVENTS WHICH SHOULD BE LIMITED BY GMP OR THERE QUALITY BASED REQUIREMENT

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Acetic acid	Heptane
Acetone	Isobutyl acetate
1-butanol	Isopropyl acetate
2-butanol	Methyl acetate
Butyl acetate	3-methyl 1-butanol
Dimethylsulfoxide	Pentane
Ethanol	1-pentanol
Ethyl acetate	1-propanol
Ethyl ether	2-propanol
Formic acid	Propyl acetate

D) Class 4 solvents (solvents for which no adequate toxicological data was found)

Some solvents may also be interest to manufacturers of excipients, drug substance, or drug products for e.g. Petroleum ether, isopropyl ether. However, no adequate toxicological data on which to base a PDE was found [8]

METHODS OF PREPARATION OF SOLID DISPERSIONS

Various methods have been developed for preparation of solid dispersions, these methods deal with the challenge of mixing a matrix and a drug, preferably on a molecular level, while matrix and drug are generally poorly miscible. During many of the preparation techniques, demixing (partially or complete), and formation of different phases is observed. Phase separations like crystallization or formation of amorphous drug clusters are difficult to control and therefore unwanted. Various preparative methods are shown in **Fig 2.3** [9]

METHODS OF PREPARATION OF SOLID DISPERSION

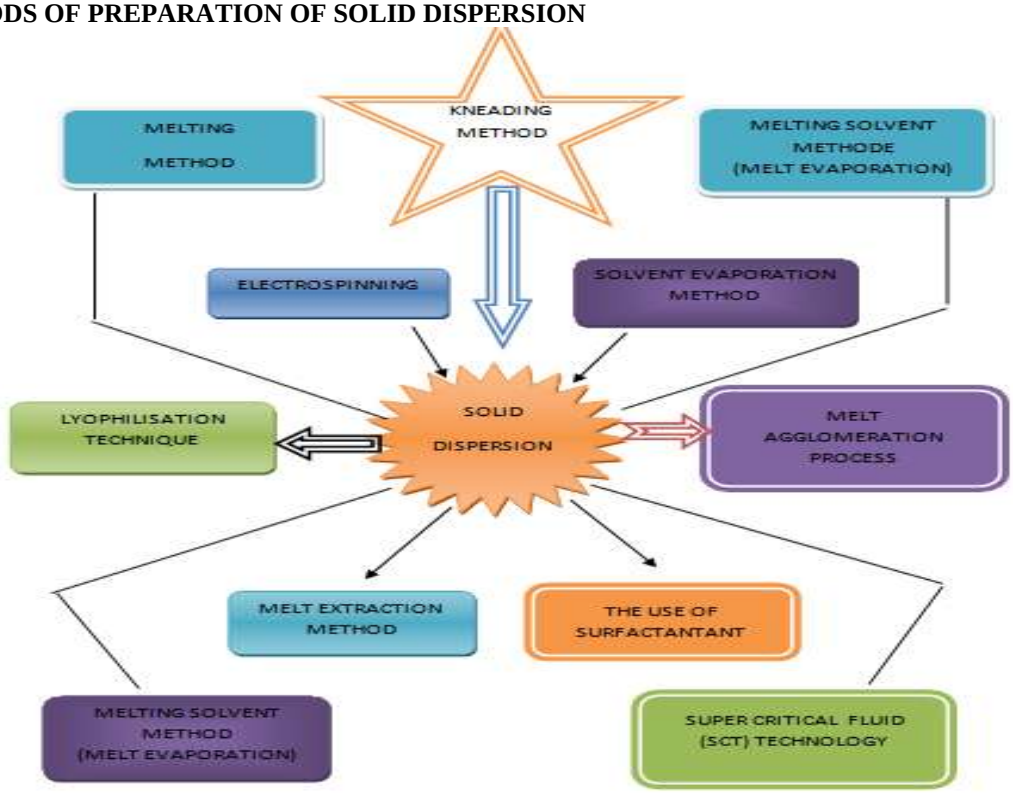

FIGURE.NO:3 METHOD OF PREPARATION

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a) Solvent evaporation method

In solvent-evaporation method, both drug and the carrier are dissolved in a common solvent with the help of a magnetic stirrer and evaporate the solution under vacuum. Then the produced mass is placed in a desiccator for 1-2 days depends upon the removal rate of solvent for drying purpose.

b) Modified solvent evaporation method

In solvent-evaporation method, both drug and the carrier are dissolved in a common solvent with the help of a magnetic stirrer and evaporate the solution under vacuum. Then the produced mass is placed in a desiccator for 1-2 days depends upon the removal rate of solvent for drying purpose. [9]

c) Fusion method (Melting method)

Melting method was first introduced by Sekiguchi and Obi. When the starting material is crystalline, than fusion method is also referred as melt method. It consists of a physical mixture of drug and water soluble carrier. Then the physical mixture is placed on ice-bath for solidification. Then it is crushed, pulverized and sieved. The first solid dispersion for pharmaceutical use consists of sulfathiazole and urea as a matrix is prepared by fusion method. If high temperature is used then many drugs and carriers may often evaporates or may be decomposed. So, to avoid this problem the physical mixture should be heated in a sealed container or in the presence of an inert gas like Nitrogen. Therefore, use of high temperature is the limitation of this method. [10]

d) Solvent melting method

This method involves the unique advantages of both the solvent and fusion method. It involves the preparation of solid dispersion by dissolving the drug into suitable liquid solvent and then incorporating the solution directly into the polymer (PEG). This is further evaporated until clear solvent free-film. Film is further dried to a constant weight. From a practical point of view it is only limited to drugs with low therapeutic dose ex: below 50 mg. [11],[12]

e) Kneading method

The physical mixture of drug and carrier were triturated using small quantity of organic solvents and water mixture, usually alcohol and water (1:1v/v). The slurry is kneading for 60mintues and dried under vaccum for 24hours. The dried mass is pulverized and sieved through sieve No.60 and stored in a desiccator. The advantages of this method are low temperature requirement for solid dispersion preparation and usage of organic solvent is less.[13]

f) Co-Grinding method

Accurately weighed drug powder and the carrier are mixed for some time using a blender at a specified speed. The mixture is then charged into the chamber of a vibration ball mill. A certain number of steel balls are added. The powder mixture is ground. Then the sample is collected and kept at room temperature in a screw capped glass vial until use.

g) Co-precipitation method (co-evaporates)

Accurately weighed carrier is dissolved in water and drug is dissolved in organic solvent. After complete dissolution, the aqueous solution of carrier is then poured into the organic solution of the drug. The solvents are then evaporated. The dispersion is pulverized with pestle and mortar, sieved and dried.[9]

h) Spray drying method

It is one of the most commonly used solvent evaporation procedures in the production of solid dispersions. It consists of dissolving or suspending the drug and carrier, then spraying it into a stream of heated air flow to remove the solvent. It is simple and cost effective, as it is 30-50 times less expensive than freeze drying.[14]

i) Gel entrapment technique

Carrier which have tendency to swell is dissolved in suitable organic solvent to form a clear and transparent gel. The drug is then dissolved in gel by sonication for few minutes. organic solvent is evaporated under vacuum. Solid dispersions are reduced in size by glass mortar and sieved.

j) Direct capsule filling

Direct filling of hard gelatin capsules with the liquid melt of solid dispersions avoids grinding induced changes in the crystallinity of the drug. This molten dispersion forms a solid plug inside the capsule on cooling to room temperature, reducing cross contamination and operator exposure in a dust-free environment, better fill weight and content uniformity was obtained than with the powder-fill technique. However, PEG was not a suitable carrier for the direct capsule-filling method as the water-soluble carrier dissolved more rapidly

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than the drug, resulting in drug-rich layers formed over the surface of dissolving plugs, which prevented further dissolution of the drug.[9]

k) Lyophilization technique

Lyophilization technique has been thought of a molecular mixing technique in which drug and carrier are co-dissolved in common solvent, frozen and sublimed to obtain a lyophilized molecular dispersion. Various scientists have successfully investigated the potential application of lyophilization in manufacturing solid dispersions.[11]

l) Electrostatic spinning method

Electrostatic spinning is a process in which solid fibers are produced from a polymeric solid fluid stream solution or melt delivered through a millimeter-scale nozzle. In this process electrostatic field involved over a conductive capillary attaching to a reservoir containing a polymeric solution and a conductive collective screen.[11]

m) Supercritical fluid technology

Supercritical fluid methods are mostly applied with carbon dioxide (CO2), which is used as either a solvent for drug and matrix or as an anti-solvent. When supercritical CO_2 is used as solvent, matrix and drug are dissolved and sprayed through a nozzle, into an expansion vessel with lower pressure and particles are immediately formed. The adiabatic expansion of the mixture results in rapid cooling. This technique does not require the use of organic solvents and since CO_2 is considered environmentally friendly, this technique is referred to as 'solvent free'. The technique is known as Rapid Expansion of Supercritical Solution (RESS). However, the application of this technique is very limited, because the solubility in CO_2 of most pharmaceutical compounds is very low (<0.01wt-%) and decreases with increasing polarity. Therefore, scaling up this process to kilogram-scale will be impractical. All other supercritical techniques are precipitation methods. Although generally labelled as solvent-free, all these supercritical fluid methods use organic solvents to dissolve drug and matrix and exploit the low solubility of pharmaceutical compounds in CO_2. In fact, these techniques represent alternative methods to remove solvents from a solution containing typically a drug and a polymer. [15]

n) Dropping solution method

The dropping method facilitate the crystallization of different chemicals and produces round particles from melted solid dispersions. In laboratory-scale preparation, a solid dispersion of a melted drug-carrier mixture is pipetted and then dropped onto a plate, where it solidifies into round particles. The size and shape of the particles can be influenced by factors such as the viscosity of the melt and the size of the pipette. Because viscosity is highly temperature-dependent, it is very important to adjust the temperature so that when the melt is dropped onto the plate it solidifies to a spherical shape. The use of carriers that solidify at room temperature may aid the dropping process. The dropping method not only simplifies the manufacturing process, but also gives a higher dissolution rate.It does not use organic solvents and, therefore, has none of the problems associated with solvent evaporation. The method also avoids the pulverization, sifting and compressibility difficulties encountered with the other melt methods. Disadvantages of the dropping method are that only thermostable drugs can be used and the physical instability of solid dispersions is a further challenge.[9]

various issues that impeded the commercial development of solid dispersions include

a) Inability to scale bench top formulation to manufacturing seized batches,
B) Difficult to control physiochemical properties,
C) Difficult in delivering solid dispersion formulations as tablet or capsule dosage forms,
D) Physical and chemical instability of drug and or the formulation itself [16]

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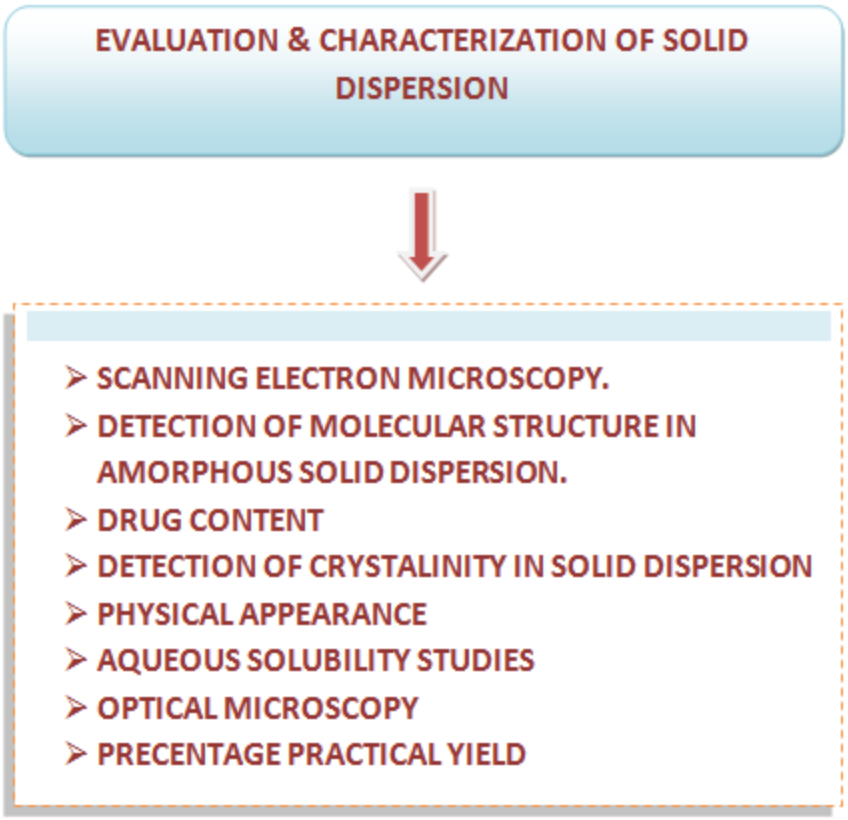
EVALUATION & CHARACTERIZATION OF SOLID DISPERSION



1. **Physical appearance**
Includes visual inspection of solid dispersions.

2. **Percent Practical Yield**

Percentage practical yield was calculated to know about percent yield or efficiency of any methods thus its help in selection of appropriate method of production. SDs were collected and weighed to determine practical yield (PY) from the following equation.

PY (%) = [Practical Mass (Solid dispersion) /Theoretical Mass (Drug+ Carrier)×100

3. **Drug content**

In this method definite amount of solid dispersion is taken and dissolved in a suitable solvent in which drug is freely soluble, then after appropriate dilution concentration are measured by UV Spectrophotometry.[5]

4. **Optical microscopy**

The optical microscopy method using calibrated ocular and stage micrometer can be utilized for particle size analysis of powder. A number of particles are measured and mean diameter is calculated.

5. **Scanning electron microscopy (SEM)**

Electron microscopy techniques such as SEM are very useful in ascertaining the particle size and morphology of solid particles. It uses electron transmitted from the specimen surface.[17]

4. **Aqueous solubility studies**

It is carried out to determine solubility drug alone in aqueous medium and also in presence of carriers .This is done by dissolving excess drug in different flasks containing different concentration of carrier in distilled water. The flasks are shaken thoroughly for 6 hours and kept aside for 24hours. The suspensions are filtered diluted suitably and absorbance is measured at suitable wavelength.

5. **Dissolution Studies**

Dissolution studies are the most significant evaluation parameter for any solid dosage form. Dissolution study is carried out to determine the rate and extent of dissolution. The dissolution studies of solid dispersion is performed

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in 900ml at 37ºC by the USP- II paddle or USP-I basket apparatus at 50-100 rpm. Drug is dispersed in medium. Aliquots of 5 ml from the dissolution medium are withdrawn at different time interval and replenished by an equal volume of fresh dissolution medium. The samples are filtered through Whatmann filter paper and analyzed for drug contents by measuring the absorbance at suitable wavelength using Shimadzu1700 UV/visible Spectrophotometer.

6) **Drug carrier compatibility**

This study is done to determine the interactions if any between the drug and carrier and to determine the formation of inclusion complexes. Methods used for this purpose are:

A) **Fourier Transform Infra Red (FTIR) Spectroscopy**

Infrared studies are carried out to rule out interaction between drug and carrier used in formulation of solid dispersion by potassium bromide disc method using Infrared spectrophotometer.

B) **Differential Scanning Calorimetry**

Differential scanning calorimetry is performed by Differential scanning calorimeter to obtain suitable thermograms. The accurately weighed sample is placed in an aluminium pan and an empty aluminium pan is used as reference. The experiment is performed under nitrogen flow, at a scanning rate 300C/min. in range of 50-3500C.[5]

7) Detection of crystallinity in solid dispersions

Powder X-ray diffraction can be used to qualitatively detect material with long range order. Sharper diffraction peaks indicate more crystalline material.Isothermal Microcalorimetry measures the crystallization energy of amorphous material that is heated above its glass transition temperature (Tg). However, this technique has some limitations. Firstly, this technique can only be applied if the physical stability is such that only during the measurement crystallization takes place. Secondly, it has to be assumed that all amorphous material crystallizes. Thirdly, in a binary mixture of two amorphous compounds a distinction between crystallization energies of drug and matrix is difficult.

Dissolution Calorimetry measures the energy of dissolution, which is dependent on the crystallinity of the sample. Usually, dissolution of crystalline material is endothermic, whereas dissolution of amorphous material is exothermic.

Density measurements and Dynamic Mechanical Analysis (DMA) determine the modulus of elasticity and viscosity and thus affected by the degree of crystallinity. However, also these techniques require knowledge about the additivity of these properties in intimately mixed binary solids.

4. **Detection of molecular structure in amorphous Solid dispersions**

Confocal Raman Spectroscopy is used to measure the homogeneity of the solid mixture.Using IR or FTIR, the extent of interactions between drug and matrix can be measured. The interactions are indicative for the mode of incorporation of the drug, because separately dispersed drug molecules will have more drug-matrix interactions than when the drug is present in amorphous clusters or other multi-molecule arrangements.

Temperature Modulated Differential Scanning Calorimetry (TMDSC) can be used to assess the degree of mixing of an incorporated drug. Due to the modulation, reversible and irreversible events can be separated. Furthermore, the value of the Tg is a function of the composition of the homogeneously mixed solid dispersion. It has been shown that the sensitivity of TMDSC is higher than conventional DSC. Therefore this technique can be used to assess the amount of molecularly dispersed drug, and from that the fraction of drug that is dispersed as separate molecules is calculated.[15]

APPLICATIONS OF SOLID DISPERSION

Solid dispersion systems can provide numerous additional benefits; some of them are as follows.

1. In improving immunosuppressive therapy in lung transplant patients, dry powder formulation consisting of a solid dispersion (e.g. Cyclosporine A) for inhalation is prepared. It can avoid many problems like use of local anaesthesia and irritating solvents.
2. Solid dispersion formulations were demonstrated to accelerate the onset of action for drugs such as nonsteroidal anti-inflammatory drugs (NSAIDS) where immediacy of action is crucial in relieving acute pain and inflammation.
3. Solid dispersion systems were shown to provide bio available oral dosage forms for anti-cancer drugs, which could be substituted for standard injections to improve patient comfort and compliance.

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4. Solid dispersion systems were also found to reduce food effect on drug absorption, thus increasing the convenience of drug therapy as the need for some drugs to be taken with food was eliminated.
5. Solid dispersion- based dosage form allowed for greater drug loading per dose and improved stability over a soft gelatin capsule formulation which thereby improved the convenience of drug therapy by reducing the dosing regimen and eliminating the need for refrigerated storage.
6. Improved absorption efficiency demonstrated for solid dispersion systems allows for a reduction in the content of active agent per dose, thus decreasing the cost associated with these drug therapies.
7. It also act as a functional carriers that offer the added benefit of targeting the release of highly soluble forms of poorly water soluble drugs to an optimum site for absorption.
8. To obtain a homogeneous distribution of a small amount of drug in solid state.
9. To stabilize the unstable drug
10. To reduce pre systemic inactivation of drugs like morphine and progesterone
11. To formulate sustained release regimen of soluble drugs by using poorly soluble or insoluble carriers
12. To formulate a fast release primary dose in a sustained released dosage form
13. To dispense liquid (up to 10%) or gaseous compounds in a solid dosage

These benefits demonstrate the current contributions and future potential of solid dispersion systems toward improving drug therapies for a variety of important medical conditions whose treatment involves poorly water soluble drugs.[9],[2]

EXAMPLES OF SOLID DISPERSIONS IN MARKET [12]

Sporanox® (itraconazole)
Intelence® (etravirine)
Prograf® (tacrolimus)
Crestor® (rosuvastatin)
Gris-PEG® (griseofulvin)
Cesamet® (nabilone)

FUTURE PROSPECTS IN SOLID DISPERSION

Successful development of solid dispersion system for clinical, preclinical and commercial use have been feasible in recent years due to the availability of surface active and surface emulsifying carriers with relatively low melting points. Because of the simplicity and manufacturing and scale up processes the physicochemical properties and the bioavailability are not expected to change during the scale up. Due to this the popularity of solid dispersions to solve bioavailability issues with respect to poorly water soluble drugs will grow rapidly. One major area of research will be the identification of new surface active and self-emulsifying carriers for solid dispersion. Only a small number of such carriers are available for oral use. One limitation in the development of solid dispersion may be the inadequate drug solubility in carrier so there has to be a wider choice of carriers. There should also be research for identification of excipients that can prevent crystallization of drugs from supersaturated systems. Physical and chemical stability of both the drug and carrier in a solid dispersion are major issues so research also needs to be done towards stability issues. [18]

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REFERENCES:

[1]. **Devender Singh Rathore., Reeta Rani Thakur., Sonia Narwal., 2011**. "Solid dispersion a new horizen in novel drug delivery system"**.** J. Pharm. Res. Vol.5 (2) 1007-1014.

[2]. Singh Jaskirat , Walia Manpreet , Harikumar S L.,2013. Solubility enhancement by solid dispersion method: A Review 3(5), 148-155.

[3]. **Irin Dewan., Ayub Hossain Md., Ashraful Islam SM., 2012** "formulation and evaluation of solid dispersions of carvedilol, a poorly water Soluble drug by using different polymers" Int Res J Pharmacy and chemistry, 2(3) 585-593.

[4]. Sameer Singh., Raviraj Singh Baghel., Lalit Yadav., 2011. A Review On Solid Dispersion.Int. J. of Pharm. & Life Sci., Vol. 2, (9) 1078-109.

[5]. **Dixit A. K., Singh R. P., Singh Stuti., 2012**. "Solid Dispersion-A strategy for improving the solubility of poorly soluble drugs". Int. J. Res. in Pharm. And biomed. sci. Vol .3(2).

[6]. **Naveen Dutt Dixit, Suneel Kumar Niranjan., 2014.** World Journal Of Pharmacy And Pharmaceutical Sciences 13.

[7]. **Bhaskar Daravath , And Rama Rao Tadikonda .,2014** Fofmulation And In Vitro Evaluation Of Flurbiprofen-Poiyethyiene Glycol 20000 Solid Dispersions.

[8]. **Amrit Paudel. Guyn Van Den Moote.**, **2011**. Influence Of Solvent Composition On The Miscibility And Physical Stability Of Naproxen / PVP K 25 Solid Dispresions Preparsions By Cosolvent Spray- Drying.

[9]. **Anupama Kalia.**, **Mayur Poddar, 2011. "**Solid Dispersions: An approach towardsenhancing dissolution rate" Int J Pharm Pharm Sci, Vol 3, (4), 9-19.

[10]. **Devender Singh Rathore., Reeta Rani Thakur., Sonia Narwal., 2011**. "Solid dispersion a new horizen in novel drug delivery system"**.** J. Pharm. Res. Vol.5 (2) 1007-1014.

[11]. **Sarkar B,Jain Devananda ,Agarwal A.Panwar A.S .**, **2011**. Effect Of Sustained Solid Dispersions On Dissolution Of Poorly Soluble Drug:Asian Journal Of Biomedical Sciences 1(2), 08-10.

[12]. **Raymond C Rowe., Paul J Sheskey., Sian C.Owen.**, **2006.** Hand Book of Pharm. Excip.5th edition, 535-539,545-550,611-616. Published by pharmaceutical press, London.

[13]. **Ganesh Chaulang., PiyushPapel., Sharwaree Hardikar., Mukul Kelkar., Ashok Bhosale., Sagar Bhise., 2009.** Formulation and evaluation of solid dispersion of furosemide in sodium starch glycolate. Trop. J. Pharm. Res. 8(1), 43-51.

[14]. **Ingle, U.S., Gaikwad P.D., Bankar V.H., Pawar S.P., 2011**. "A review on solid dispersion: A dissolution enhancement technique". Int. J. of Res. In Ayur.and Pharm. 2 (3) 75-757.

[15]. **Arunachalam A., Karthikeyan. M., Kishore Konam., Pottabathula Hari Prasad., Sethuraman, Ashutoshkumar S. , 2010. "**Solid Dispersions-A review". Curr. Pharm. Res. Vol.1.(1).

[16]. **Puratchikody A., Kamalakannan V., Masilamani K., Senthilnathan B., 2010.**"Solubility enhancement of poorly water soluble drug by solid dispersion technique- A Review". J. Pharm. Res. 3(9), 2314-2321.

[17]. **Kalpana Patidar., Soni Manish., Sharma Dinesh K., Jain. Surendra K., 2010.** "Solid Dispersion: Approaches, Technology involved, unmet need and Challenges".Drug Inv. Today Vol.2.(7) 349-357.

[18]. **Praveen Kumar D., Arora Vandana., 2012 . "**Solid Dispersions: A Review". J. Of. Pharm. And Sci. Innov. 1(3) 27-34.